



## nonsyndromic hearing loss

Nonsyndromic hearing loss is a partial or total loss of hearing that is not associated with other signs and symptoms. In contrast, syndromic hearing loss occurs with signs and symptoms affecting other parts of the body.

Nonsyndromic hearing loss can be classified in several different ways. One common way is by the condition's pattern of inheritance: autosomal dominant (DFNA), autosomal recessive (DFNB), X-linked (DFNX), or mitochondrial (which does not have a special designation). Each of these types of hearing loss includes multiple subtypes. DFNA, DFNB, and DFNX subtypes are numbered in the order in which they were first described. For example, DFNA1 was the first type of autosomal dominant nonsyndromic hearing loss to be identified.

The characteristics of nonsyndromic hearing loss vary among the different types. Hearing loss can affect one ear (unilateral) or both ears (bilateral). Degrees of hearing loss range from mild (difficulty understanding soft speech) to profound (inability to hear even very loud noises). The term "deafness" is often used to describe severe-to-profound hearing loss. Hearing loss can be stable, or it may be progressive, becoming more severe as a person gets older. Particular types of nonsyndromic hearing loss show distinctive patterns of hearing loss. For example, the loss may be more pronounced at high, middle, or low tones.

Most forms of nonsyndromic hearing loss are described as sensorineural, which means they are associated with a permanent loss of hearing caused by damage to structures in the inner ear. The inner ear processes sound and sends the information to the brain in the form of electrical nerve impulses. Less commonly, nonsyndromic hearing loss is described as conductive, meaning it results from changes in the middle ear. The middle ear contains three tiny bones that help transfer sound from the eardrum to the inner ear. Some forms of nonsyndromic hearing loss, particularly a type called DFNX2, involve changes in both the inner ear and the middle ear. This combination is called mixed hearing loss.

Depending on the type, nonsyndromic hearing loss can become apparent at any time from infancy to old age. Hearing loss that is present before a child learns to speak is classified as prelingual or congenital. Hearing loss that occurs after the development of speech is classified as postlingual.

### Frequency

Between 2 and 3 per 1,000 children in the United States are born with detectable hearing loss in one or both ears. The prevalence of hearing loss increases with age; the

condition affects 1 in 8 people in the United States age 12 and older, or about 30 million people. By age 85, more than half of all people experience hearing loss.

## Genetic Changes

The causes of nonsyndromic hearing loss are complex. Researchers have identified more than 90 genes that, when altered, are associated with nonsyndromic hearing loss. Many of these genes are involved in the development and function of the inner ear. Mutations in these genes contribute to hearing loss by interfering with critical steps in processing sound. Different mutations in the same gene can be associated with different types of hearing loss, and some genes are associated with both syndromic and nonsyndromic forms. In many affected families, the factors contributing to hearing loss have not been identified.

Most cases of nonsyndromic hearing loss are inherited in an autosomal recessive pattern. About half of all severe-to-profound autosomal recessive nonsyndromic hearing loss results from mutations in the *GJB2* gene; these cases are designated DFNB1. The *GJB2* gene provides instructions for making a protein called connexin 26, which is a member of the connexin protein family. Mutations in another connexin gene, *GJB6*, can also cause DFNB1. The *GJB6* gene provides instructions for making a protein called connexin 30. Connexin proteins form channels called gap junctions, which allow communication between neighboring cells, including cells in the inner ear. Mutations in the *GJB2* or *GJB6* gene alter their respective connexin proteins, which changes the structure of gap junctions and may affect the function or survival of cells that are needed for hearing.

The most common cause of moderate autosomal recessive nonsyndromic hearing loss is mutations in the *STRC* gene. These mutations cause a form of the condition known as DFNB16. Mutations in more than 60 other genes can also cause autosomal recessive nonsyndromic hearing loss. Many of these gene mutations have been found in one or a few families.

Nonsyndromic hearing loss can also be inherited in an autosomal dominant pattern. Mutations in at least 30 genes have been identified in people with autosomal dominant nonsyndromic hearing loss; mutations in some of these genes (including *GJB2* and *GJB6*) can also cause autosomal recessive forms of the condition. Although no single gene is associated with a majority of autosomal dominant nonsyndromic hearing loss cases, mutations in a few genes, such as *KCNQ4* and *TECTA*, are relatively common. Mutations in many of the other genes associated with autosomal dominant nonsyndromic hearing loss have been found in only one or a few families.

X-linked and mitochondrial forms of nonsyndromic hearing loss are rare. About half of all X-linked cases are caused by mutations in the *POU3F4* gene. This form of the condition is designated DFNX2. Mutations in at least three other genes have also been identified in people with X-linked nonsyndromic hearing loss.

Mitochondrial forms of hearing loss result from changes in mitochondrial DNA (mtDNA). Mitochondria are structures within cells that convert the energy from food into a form that cells can use. Although most DNA is packaged in chromosomes within the nucleus, mitochondria also have a small amount of their own DNA. Only a few mutations in mtDNA have been associated with hearing loss, and their role in the condition is still being studied.

Mutations in some of the genes associated with nonsyndromic hearing loss can also cause syndromic forms of hearing loss, such as Usher syndrome (*CDH23* and *MYO7A*, among others), Pendred syndrome (*SLC26A4*), Wolfram syndrome (*WFS1*), and Stickler syndrome (*COL11A2*). It is often unclear how mutations in the same gene can cause isolated hearing loss in some individuals and hearing loss with additional signs and symptoms in others.

In addition to genetic changes, hearing loss can result from environmental factors or a combination of genetic risk and a person's environmental exposures. Environmental causes of hearing loss include certain medications, specific infections before or after birth, and exposure to loud noise over an extended period. Age is also a major risk factor for hearing loss. Age-related hearing loss (presbycusis) is thought to have both genetic and environmental influences.

## **Inheritance Pattern**

As discussed above, nonsyndromic hearing loss has different patterns of inheritance. Between 75 and 80 percent of cases are inherited in an autosomal recessive pattern, which means both copies of the gene in each cell have mutations. Usually, each parent of an individual with autosomal recessive hearing loss carries one copy of the mutated gene but does not have hearing loss.

Another 20 to 25 percent of nonsyndromic hearing loss has an autosomal dominant pattern of inheritance, which means one copy of the altered gene in each cell is sufficient to cause the condition. Most people with autosomal dominant hearing loss inherit an altered copy of the gene from a parent who also has hearing loss.

Between 1 and 2 percent of cases have an X-linked pattern of inheritance. A condition is considered X-linked if the mutated gene that causes the disorder is located on the X chromosome, one of the two sex chromosomes in each cell. Males with X-linked nonsyndromic hearing loss tend to develop more severe hearing loss earlier in life than females who inherit a copy of the same gene mutation. A characteristic of X-linked inheritance is that fathers cannot pass X-linked traits to their sons.

Mitochondrial forms of the condition, which result from changes to mtDNA, account for less than 1 percent of all nonsyndromic hearing loss in the United States. These cases are inherited in a mitochondrial pattern, which is also known as maternal inheritance. This pattern of inheritance applies to genes contained in mtDNA. Because egg cells, but not sperm cells, contribute mitochondria to the developing embryo, children

can only inherit disorders resulting from mtDNA mutations from their mother. These disorders can appear in every generation of a family and can affect both males and females, but fathers do not pass traits associated with changes in mtDNA to their children.

In some cases, hearing loss occurs in people with no history of the condition in their family. These cases are described as sporadic, and the cause of the hearing loss is often unknown. When hearing loss results from environmental factors, it is not inherited.

### **Other Names for This Condition**

- isolated deafness
- nonsyndromic deafness
- nonsyndromic hearing impairment
- nonsyndromic hearing loss and deafness

### **Diagnosis & Management**

These resources address the diagnosis or management of nonsyndromic hearing loss:

- Baby's First Test: Hearing Loss  
<http://www.babysfirsttest.org/newborn-screening/conditions/hearing-loss>
- GeneReview: Deafness and Hereditary Hearing Loss Overview  
<https://www.ncbi.nlm.nih.gov/books/NBK1434>
- Genetic Testing Registry: Deafness, X-linked  
<https://www.ncbi.nlm.nih.gov/gtr/conditions/CN043651/>
- Genetic Testing Registry: Hereditary hearing loss and deafness  
<https://www.ncbi.nlm.nih.gov/gtr/conditions/C0236038/>
- Genetic Testing Registry: Non-syndromic genetic deafness  
<https://www.ncbi.nlm.nih.gov/gtr/conditions/CN043648/>
- MedlinePlus Encyclopedia: Age-related hearing loss  
<https://medlineplus.gov/ency/article/001045.htm>
- MedlinePlus Encyclopedia: Audiology  
<https://medlineplus.gov/ency/article/003341.htm>
- MedlinePlus Encyclopedia: Hearing loss  
<https://medlineplus.gov/ency/article/003044.htm>
- MedlinePlus Encyclopedia: Hearing or speech impairment - resources  
<https://medlineplus.gov/ency/article/002152.htm>

These resources from MedlinePlus offer information about the diagnosis and management of various health conditions:

- Diagnostic Tests  
<https://medlineplus.gov/diagnostictests.html>
- Drug Therapy  
<https://medlineplus.gov/drugtherapy.html>
- Surgery and Rehabilitation  
<https://medlineplus.gov/surgeryandrehabilitation.html>
- Genetic Counseling  
<https://medlineplus.gov/geneticcounseling.html>
- Palliative Care  
<https://medlineplus.gov/palliativecare.html>

## **Additional Information & Resources**

### MedlinePlus

- Encyclopedia: Age-related hearing loss  
<https://medlineplus.gov/ency/article/001045.htm>
- Encyclopedia: Audiology  
<https://medlineplus.gov/ency/article/003341.htm>
- Encyclopedia: Hearing loss  
<https://medlineplus.gov/ency/article/003044.htm>
- Encyclopedia: Hearing or speech impairment - resources  
<https://medlineplus.gov/ency/article/002152.htm>
- Health Topic: Hearing Disorders and Deafness  
<https://medlineplus.gov/hearingdisordersanddeafness.html>
- Health Topic: Hearing Problems in Children  
<https://medlineplus.gov/hearingproblemsinchildren.html>
- Health Topic: Newborn Screening  
<https://medlineplus.gov/newbornscreening.html>

### Additional NIH Resources

- National Institute on Deafness and Other Communication Disorders  
<https://www.nidcd.nih.gov/health/hearing-ear-infections-deafness>

## Educational Resources

- American Academy of Otolaryngology: Genes and Hearing Loss  
<http://www.entnet.org/content/genes-and-hearing-loss>
- Boston Children's Hospital  
<http://www.childrenshospital.org/conditions-and-treatments/conditions/h/hearing-loss>
- Centers for Disease Control and Prevention: Hearing Loss in Children  
<https://www.cdc.gov/ncbddd/hearingloss/>
- Centre for Genetics Education (Australia)  
<http://www.genetics.edu.au/Publications-and-Resources/Genetics-Fact-Sheets/FS63DEAFNESSANDHEARINGLOSS.pdf>
- Disease InfoSearch: Deafness  
<http://www.diseaseinfosearch.org/Deafness/2125>
- Harvard Medical School Center for Hereditary Deafness  
<http://hearing.harvard.edu/>
- Hereditary Hearing Loss Homepage  
<http://hereditaryhearingloss.org/>
- Kennedy Krieger Institute  
<https://www.kennedykrieger.org/patient-care/diagnoses-disorders/hearing-impairment>
- KidsHealth from the Nemours Foundation  
<http://kidshealth.org/en/kids/hearing-impairment.html>
- Laurent Clerc National Deaf Education Center, Gallaudet University  
<http://www.gallaudet.edu/clerc-center.html>
- MalaCards: autosomal dominant nonsyndromic deafness  
[http://www.malacards.org/card/autosomal\\_dominant\\_nonsyndromic\\_deafness](http://www.malacards.org/card/autosomal_dominant_nonsyndromic_deafness)
- MalaCards: autosomal recessive nonsyndromic deafness  
[http://www.malacards.org/card/autosomal\\_recessive\\_nonsyndromic\\_deafness](http://www.malacards.org/card/autosomal_recessive_nonsyndromic_deafness)
- MalaCards: nonsyndromic hearing loss and deafness  
[http://www.malacards.org/card/nonsyndromic\\_hearing\\_loss\\_and\\_deafness](http://www.malacards.org/card/nonsyndromic_hearing_loss_and_deafness)
- MalaCards: x-linked nonsyndromic deafness  
[http://www.malacards.org/card/x\\_linked\\_nonsyndromic\\_deafness](http://www.malacards.org/card/x_linked_nonsyndromic_deafness)
- March of Dimes: Hearing Impairment  
<http://www.marchofdimes.org/baby/hearing-impairment.aspx>

- Merck Manual Consumer Version  
<http://www.merckmanuals.com/home/ear-nose-and-throat-disorders/hearing-loss-and-deafness/hearing-loss>
- My46 Trait Profile  
<https://www.my46.org/trait-document?trait=Nonsyndromic%20congenital%20hearing%20loss&type=profile>
- Orphanet: Non-syndromic genetic deafness  
[http://www.orpha.net/consor/cgi-bin/OC\\_Exp.php?Lng=EN&Expert=87884](http://www.orpha.net/consor/cgi-bin/OC_Exp.php?Lng=EN&Expert=87884)
- The Connexin-Deafness Homepage  
<http://davinci.crg.es/deafness/>
- World Health Organization: Deafness and Hearing Loss  
<http://www.who.int/mediacentre/factsheets/fs300/en/>

#### Patient Support and Advocacy Resources

- Contact a Family (UK)  
<http://www.cafamily.org.uk/medical-information/conditions/d/deafness/>
- Hearing Health Foundation  
<http://hearinghealthfoundation.org/>
- John Tracy Clinic  
<http://www.jtc.org>
- My Baby's Hearing, Boys Town National Research Hospital  
<http://www.babyhearing.org/>
- National Association of the Deaf  
<https://www.nad.org/>
- National Center for Hearing Assessment and Management, Utah State University  
<http://www.infanthearing.org/>
- Resource List from the University of Kansas Medical Center  
<http://www.kumc.edu/gec/support/hearing.html>

#### GeneReviews

- Deafness and Hereditary Hearing Loss Overview  
<https://www.ncbi.nlm.nih.gov/books/NBK1434>
- DFNA2 Nonsyndromic Hearing Loss  
<https://www.ncbi.nlm.nih.gov/books/NBK1209>
- DFNX1 Nonsyndromic Hearing Loss and Deafness  
<https://www.ncbi.nlm.nih.gov/books/NBK57098>

- Nonsyndromic Hearing Loss and Deafness, DFNA3  
<https://www.ncbi.nlm.nih.gov/books/NBK1536>
- Nonsyndromic Hearing Loss and Deafness, DFNB1  
<https://www.ncbi.nlm.nih.gov/books/NBK1272>
- Nonsyndromic Hearing Loss and Deafness, Mitochondrial  
<https://www.ncbi.nlm.nih.gov/books/NBK1422>
- OTOF-Related Deafness  
<https://www.ncbi.nlm.nih.gov/books/NBK1251>
- TBC1D24-Related Disorders  
<https://www.ncbi.nlm.nih.gov/books/NBK274566>
- WFS1-Related Disorders  
<https://www.ncbi.nlm.nih.gov/books/NBK4144>

### Genetic Testing Registry

- Deafness, X-linked  
<https://www.ncbi.nlm.nih.gov/gtr/conditions/CN043651/>
- Hereditary hearing loss and deafness  
<https://www.ncbi.nlm.nih.gov/gtr/conditions/C0236038/>
- Non-syndromic genetic deafness  
<https://www.ncbi.nlm.nih.gov/gtr/conditions/CN043648/>

### ACT Sheets

- Congenital hearing loss >~30db  
[https://www.ncbi.nlm.nih.gov/books/NBK55827/bin/Hearing\\_Loss.pdf](https://www.ncbi.nlm.nih.gov/books/NBK55827/bin/Hearing_Loss.pdf)

### ClinicalTrials.gov

- ClinicalTrials.gov  
<https://clinicaltrials.gov/ct2/results?cond=%22nonsyndromic+deafness%22+OR+%22Hearing+Loss%22+OR+%22Deafness%22>

### Scientific articles on PubMed

- PubMed  
[https://www.ncbi.nlm.nih.gov/pubmed?term=%28%28Deafness%5BMAJR%5D%29+OR+%28hearing+loss%5BMAJR%5D%29%29+AND+%28%28nonsyndromic%5BTIAB%5D%29+OR+%28DFNA\\*%5BTI%5D%29+OR+%28DFNB\\*%5BTI%5D%29+OR+%28DFNX\\*%5BTI%5D%29%29+AND+english%5BIa%5D+AND+human%5Bmh%5D+AND+%22last+720+days%22%5Bdp%5D](https://www.ncbi.nlm.nih.gov/pubmed?term=%28%28Deafness%5BMAJR%5D%29+OR+%28hearing+loss%5BMAJR%5D%29%29+AND+%28%28nonsyndromic%5BTIAB%5D%29+OR+%28DFNA*%5BTI%5D%29+OR+%28DFNB*%5BTI%5D%29+OR+%28DFNX*%5BTI%5D%29%29+AND+english%5BIa%5D+AND+human%5Bmh%5D+AND+%22last+720+days%22%5Bdp%5D)



## OMIM

- DEAFNESS, AMINOGLYCOSIDE-INDUCED  
<http://omim.org/entry/580000>
- DEAFNESS, AUTOSOMAL DOMINANT 2A  
<http://omim.org/entry/600101>
- DEAFNESS, AUTOSOMAL DOMINANT 3A  
<http://omim.org/entry/601544>
- DEAFNESS, AUTOSOMAL DOMINANT 4A  
<http://omim.org/entry/600652>
- DEAFNESS, AUTOSOMAL DOMINANT 5  
<http://omim.org/entry/600994>
- DEAFNESS, AUTOSOMAL DOMINANT 6  
<http://omim.org/entry/600965>
- DEAFNESS, AUTOSOMAL DOMINANT 7  
<http://omim.org/entry/601412>
- DEAFNESS, AUTOSOMAL DOMINANT 9  
<http://omim.org/entry/601369>
- DEAFNESS, AUTOSOMAL DOMINANT 10  
<http://omim.org/entry/601316>
- DEAFNESS, AUTOSOMAL DOMINANT 11  
<http://omim.org/entry/601317>
- DEAFNESS, AUTOSOMAL DOMINANT 12  
<http://omim.org/entry/601543>
- DEAFNESS, AUTOSOMAL DOMINANT 12  
<http://omim.org/entry/601543>
- DEAFNESS, AUTOSOMAL DOMINANT 13  
<http://omim.org/entry/601868>
- DEAFNESS, AUTOSOMAL DOMINANT 15  
<http://omim.org/entry/602459>
- DEAFNESS, AUTOSOMAL DOMINANT 20  
<http://omim.org/entry/604717>
- DEAFNESS, AUTOSOMAL DOMINANT 22  
<http://omim.org/entry/606346>
- DEAFNESS, AUTOSOMAL DOMINANT 23  
<http://omim.org/entry/605192>

- DEAFNESS, AUTOSOMAL DOMINANT 36  
<http://omim.org/entry/606705>
- DEAFNESS, AUTOSOMAL DOMINANT 43  
<http://omim.org/entry/608394>
- DEAFNESS, AUTOSOMAL DOMINANT 48  
<http://omim.org/entry/607841>
- DEAFNESS, AUTOSOMAL DOMINANT 52  
<http://omim.org/entry/607683>
- DEAFNESS, AUTOSOMAL RECESSIVE  
<http://omim.org/entry/607197>
- DEAFNESS, AUTOSOMAL RECESSIVE 1A  
<http://omim.org/entry/220290>
- DEAFNESS, AUTOSOMAL RECESSIVE 2  
<http://omim.org/entry/600060>
- DEAFNESS, AUTOSOMAL RECESSIVE 3  
<http://omim.org/entry/600316>
- DEAFNESS, AUTOSOMAL RECESSIVE 7  
<http://omim.org/entry/600974>
- DEAFNESS, AUTOSOMAL RECESSIVE 9  
<http://omim.org/entry/601071>
- DEAFNESS, AUTOSOMAL RECESSIVE 12  
<http://omim.org/entry/601386>
- DEAFNESS, AUTOSOMAL RECESSIVE 13  
<http://omim.org/entry/603098>
- DEAFNESS, AUTOSOMAL RECESSIVE 16  
<http://omim.org/entry/603720>
- DEAFNESS, AUTOSOMAL RECESSIVE 17  
<http://omim.org/entry/603010>
- DEAFNESS, AUTOSOMAL RECESSIVE 18A  
<http://omim.org/entry/602092>
- DEAFNESS, AUTOSOMAL RECESSIVE 20  
<http://omim.org/entry/604060>
- DEAFNESS, AUTOSOMAL RECESSIVE 21  
<http://omim.org/entry/603629>
- DEAFNESS, AUTOSOMAL RECESSIVE 28  
<http://omim.org/entry/609823>

- DEAFNESS, AUTOSOMAL RECESSIVE 31  
<http://omim.org/entry/607084>
- DEAFNESS, AUTOSOMAL RECESSIVE 33  
<http://omim.org/entry/607239>
- DEAFNESS, AUTOSOMAL RECESSIVE 36, WITH OR WITHOUT VESTIBULAR INVOLVEMENT  
<http://omim.org/entry/609006>
- DEAFNESS, AUTOSOMAL RECESSIVE 37  
<http://omim.org/entry/607821>
- DEAFNESS, AUTOSOMAL RECESSIVE 67  
<http://omim.org/entry/610265>
- DEAFNESS, X-LINKED 1  
<http://omim.org/entry/304500>
- DEAFNESS, X-LINKED 2  
<http://omim.org/entry/304400>
- DEAFNESS, X-LINKED 3  
<http://omim.org/entry/300030>
- DEAFNESS, X-LINKED 4  
<http://omim.org/entry/300066>
- DEAFNESS, X-LINKED 5  
<http://omim.org/entry/300614>
- DEAFNESS, X-LINKED 6  
<http://omim.org/entry/300914>

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